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CONFERENCE ON EGGS AND POULTRY

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Held at Albany, California
March 16-18, 1959

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Sponsored by Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Albany, Calif., and State Agricultural Experiment Station Directors, Western Region.

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

THE ANNUAL COLLABORATORS' CONFERENCE sponsored by the Western Utilization Research and Development Division of USDA's Agricultural Research Service and the western State Agricultural Experiment Stations was held in Albany, March 16-18, 1959. The selected subject was Poultry and Eggs.

The program was arranged by Hans Lineweaver, Chief of the Poultry Laboratory of the Western Utilization Research and Development Division, and George F. Stewart, Chairman, Department of Poultry Husbandry, University of California, Davis.

The sponsors were especially gratified by the attendance and participation of members of the Committee for the North Central Regional Marketing Project No. 7 and others outside the western region.

This publication is a report of information presented at the conference. Sixty poultry scientists were present from 25 States, extending from Massachusetts to Hawaii. Copies are available on request from Western Regional Research Laboratory, USDA, Albany 10, Calif.

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TENDERNESS OF POULTRY MEAT--TECHNOLOGICAL STUDIES AND INDUSTRY STATUS

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This area of work in poultry products has been much studied. In a survey of 20 universities, selected because of known work on Food Technology, 15 replied. Five indicated no work on tenderness but 10 poultry departments reported research on factors affecting tenderness.

The survey was aimed at finding out a little about equipment. Three stations are using the Kramer press, 5 the Warner-Bratzler device, 1 a modified Warner-Bratzler, and 1 relies on panel evaluation. All reported some comparative work between panels and a particular instrument.

With this research activity on the part of at least 10 Land Grant schools plus two USDA laboratories (Albany, Calif., and Beltsville) is it safe to assume that we have a tenderness problem?

Industry status is a variable, depending on which segment is contacted. The groups selling precooked chicken products appear to be concerned. The rapid change to fast continuous chilling procedures might bring the tenderness problem to the forefront again in the entire industry.

Three papers published in Food Technology in 1959 summarize the status of current research. These papers are: Poultry tenderness. I. Influence of processing on tenderness of turkeys, Food Technol. 13, 20-24; Poultry tenderness. II. Influence of processing on tenderness of chickens, Food Technol. 13, 25-29; Post mortem aging of poultry meat and its effect on the tenderness of the breast muscles, Food Technol. 13, 81-84. The first two came from the Laboratory here in California, the third from Purdue University.

In addition to the factors listed in the first two references, one point that we found important was the time lag after scalding prior to picking. This could be due to extended scalding. Areas of research now under way at various experiment stations are listed below.

Aging: This method is solving the tenderness problem in turkeys. The birds are aged for specified lengths of time, depending on age, after evisceration and before freezing until rigor has resolved to the degree that the meat can no longer be classified as tough.

1. Aging in water promotes much more rapid resolution of rigor than aging in air.

2. Aging at a lower temperature speeds up the resolution of rigor. Resolution at 55°F. takes approximately 3 times as long as at 32°F. Attempts are now being made to lower the temperature of the aging media below 32°F. to investigate the possibility of decreasing rigor resolution time still further.

3. The resolution of rigor in turkeys does not follow the same pattern for given times post-mortem as does resolution of rigor in chickens of the same age.

Water uptake: Because of results of research on aging, work has been undertaken on the role of water uptake in tenderization. This area of course has confounding ramifacations, because there are at present practical limits of water uptake. So far, we have been able to increase water uptake to 25% of the eviscerated carcass weight. Such figures as this, however, are meaningless unless we are able to hold the water in the tissue to eliminate excessive losses from drip during cooking. Research is under way to promote the binding of water in the muscle by addition of a low level of salts to the aging media (2% KCl). (Its approval by Food and Drug Administration should present no problem, since KCl is a constituent of many foods.) The results of preliminary studies indicate a trace increase in potassium content in the tissue after an 8-hour aging period at 32°F., and with this a slight increase in tenderness and juiciness. Work with chicken stags (12-month-old cross-breds) showed that birds aged in 2% KCl were as tender at 2 hours as the controls were at 8 hours. Additional ideas are being developed and tested within this area.

Rigor: The basic problem is the resolution of rigor mortis. Along with attempting a more rapid resolution we are trying to find out what rigor is. At present we realize it is an extremely complex chemical reaction, and, accoring to most physiologists it is very hard to trace. Although we keep in mind that we are dealing with a piece of meat, not a living product, we have found that by alteration of physical condition of the bird in the live state we can change the rigor pattern with varying degrees of success. At present we are thinking in terms of immobilization and tranquilization.

Methodology: The advances we have made in methodology of tenderness research are perhaps too numerous to evaluate in a summary such as this. We are using the Kramer Shear press in our tenderness work, and by utilizing some modifications--such as sample size and extreme care in our samples between cooking and testing we are well satisfied with it. We are attempting to devise a method of tenderness measurement on raw meat which would be an extremely great asset.

At present we can make some recommendations based on our research:

1. Turkeys should be aged in slush ice at as low a temperature as possible. Young turkeys should be aged for 8 to 10 hours before freezing, and old turkeys for 12 to 13 hours. Old toms and hens should be aged for approximately 16 hours.

2. Excitement before slaughter should be avoided, since it alters the normal rigor pattern and causes more birds to be tough, even though others are tender.

3. Aging in water is much more beneficial than aging in air, not only because of more rapid tenderization but because of a now justifiable water uptake (4-6%).

4. The bird should be allowed to bleed completely immediately after killing. In other words, it should not drown in the scalding tank. Thorough bleeding is an advantage and also promotes a more normal rate of tenderization. When a live bird is introduced into the scald water a shock is produced which can be easily seen in the pattern of tenderization; the bird appears to go into a more severe state of rigor.

FUNDAMENTAL BIOCHEMICAL STUDIES OF TENDERIZATION IN CHICKEN MUSCLE

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The chemical changes in freshly slaughtered chicken muscle have been followed under a variety of conditions. In addition, tenderness of the cooked meat has been studied as a function of these conditions. It is known from previous work on other animal species that the chemical event most closely linked to the development of rigor mortis is the breakdown of adenosine triphosphate (ATP). The ATP level is maintained in anaerobic muscle tissue at the expense of chemical energy derived from the fermentation of glycogen. When the glycogen is depleted (or the pH has dropped to inhibitory levels as a result of production of lactic acid), the breakdown of ATP proceeds rapidly. Rigor mortis commences when 1/2 to 2/3 of the ATP has disappeared.

The treatments that have been accorded to chicken muscle before onset of rigor mortis include cutting, beating, varying the post-mortem environmental temperature, freezing and thawing, exhaustive electrical stimulation, electron irradiation, and lethal injections of sodium monobromoacetate (a potent inhibitor of glycolysis). These treatments all accelerated the onset of rigor mortis. Every treatment that resulted in a more rapid rate of loss of ATP, a more rapid rate of loss of glycogen, and a more rapid drop of pH resulted in decreased tenderness of cooked meat. Lethal injections of sodium monobromoacetate (which accelerated the onset of rigor mortis) also caused a marked increase in rate of loss of ATP, but had little influence on pH or glycogen levels. In these latter cases, the tenderness of the cooked meat was the same as that of uninjected controls. This would appear to rule out the rapid loss of ATP as the determinant of increased toughness. However, the pH of these muscles was appreciably higher than normal (pH 6.5, compared to normal values of 5.7-5.9). Since the isoelectric point of actomyosin (the principal protein component of muscle) is in the neighborhood of 5.3, the higher pH would lead to greater water-binding by actomyosin, and, presumably, more tender meat. Further studies of effect of pH on tenderness of cooked muscle are required for an understanding of this phenomenon.

Table 1 presents a summary of treatments and responses.

Table 1. Treatments and their effects

Pre-rigor treatment	Increases toughness	Accelerates			
		Rigor	ATP loss	pH drop	Glycogen loss
Scalding	+				
Beating	+	(+)[1]	+	+	
Cutting	+				
Freezing	+	+	+	+	+
Electric shock	+	(+)	+	+	
Irradiation	+	+			
High temperature	+	+	+	+	
Monobromoacetate	No	+	+	No	No

[1] Parentheses mean that physical measurements on rigor were not recorded.

FROZEN POULTRY STABILITY -- EFFECTS OF TEMPERATURE, TIME, AND ATMOSPHERE

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Stability of frozen poultry products continues to be important to the poultry and food industries, because it has a strong influence on methods of processing, packaging, storage, and merchandising--and also on acceptance at the dinner table.

Practical questions continually arise. How low a temperature do we need to retain optimum quality for 3 months, 6 months, one year? What type of packaging is required? Shipments of frozen poultry may arrive at the warehouse at temperatures ranging from +20°F. to +30°F. and above. Should they be placed in a blast freezer at additional expense and rapidly cooled to 0°F., or is it sufficient to hold them at 0°F. where the temperature in the product will reach 0°F. in a matter of days? What effect do short periods at high temperatures have on subsequent storage life? What is the effect of a series of temperature fluctuations, particularly in comparison with the effect of a steady temperature equal to the mean of the fluctuations?

Such questions would appear to justify studies on the stability of frozen poultry which have been conducted in this laboratory over the past 5 years (1, 2, 3). It is important to recognize, however, that this is not a new line of work in USDA. Work was initiated in 1905, with the pioneering efforts of Mary E. Pennington, and has continued on and off ever since, both in the Department and in the State Experiment Stations (4, 5, 6, 7). Justification for additional work currently and in the future lies in new types of products, new types of packages, altered storage conditions or requirements, and an overall desire to make good products better.

Considerable emphasis has been placed on the time-temperature tolerance of frozen foods. Work that we shall discuss defines times and temperatures for first quality loss, but it will emphasize a third dimension in product stability, that of atmosphere. The data will demonstrate the value and potential for tight, oxygen-impermeable packaging and in some cases inert-gas packing for extending the storage life of frozen poultry products.

Studies were first made on 3 commercial lots of frozen, packaged, cut-up chickens, with adequacy of packaging ranging from excellent to fair to inferior for the 3 respective lots. The rate of moisture loss from the inferior package was about 10 times that observed for the excellent package. Individual packages were stored at steady temperatures of −30°, −10°, 0°, +10°, +20°, and

at conditions fluctuating between 0° and +20°F. or between -10° and +10°F. in repeated 24-hour sinusoidal cycles. After selected, successive storage periods ranging from 2 weeks to 2 years, sample packages were removed and evaluated for moisture loss, changes in appearance, peroxide development in fat, and development of off odors in the raw and off flavors in the cooked products. Organoleptic results were expressed in terms of the time required for a trained taste panel to detect significant deterioration in a sample held at an experimental temperature compared to a control sample held at 30°F.

Off odor in thawed raw meat was the first quality defect to be detected by the taste panel, followed by off flavors in the cooked meat and liver. Storage deterioration in the gizzards was manifested in a change in color of cooked tissue from blue-black to red. White, chalky, dehydrated areas on surfaces of meat reached an objectionable level when moisture loss from the package exceeded 0.5% of the carcass weight. This degree of dehydration occurred in the best package only after 10 months at +20°F., but in the worst package in one month or less.

All packaging conditions protected high quality for at least 6 months at 0°F., but there were great differences between the best and worst packages, which were mainly reflections of the differences in permeability of the packages. Chickens in the more permeable package had less than one-third the storage life of chickens in the less permeable package. Peroxide development was correlated with level of organoleptic deterioration.

Results of taste-panel tests of samples stored at +20°, +10°, and 0°F. provided further evidence to support a recommendation for storage at 0°F. or below Storage life at 0°F. was at least 6 months in the poorest package and about 2 years in the best, compared to 3 months and 10 months at +10°, and 1 month and 6 months at ±20°F. for the extremes of packaging adequacy. Temperature fluctuations had practically the same deteriorative effect as a steady temperature equal to the arithmetic mean of all fluctuations.

While these results indicate the great importance of low package permeability, they give a measure of a composite effect, that of moisture loss and oxygen availability, and of any interaction between these two consequences of poor packaging. In order to measure independently the effects of oxygen availability, moisture loss, and temperature, cut-up fryers were stored in sealed tin cans with atmospheres of nitrogen, air, and nitrogen containing 3% oxygen. Some air-packed samples were stored in the presence of a desiccant to accomplish moisture loss without altering oxyten availability, while other samples were packed in vented cans in the presence of ice cubes so as to provide unlimited availability to oxygen (air) but no significant loss of moisture from the meat.

After various storage periods sample cans were evaluated for changes in moisture content, oxygen and carbon dioxide of the atmosphere, and odor and flavor of the meat. In sealed cans, an induced rate of moisture loss (by desiccant) greater than that experienced in the most permeable commercial package failed to influence the rate of organoleptic deterioration or oxygen consumption. However, much greater deterioration was found in air packs compared to nitrogen packs, or even in 3% oxygen packs compared to nitrogen packs. Appreciable rates of deterioration in nitrogen packs at +20° or +10°F. compared to -30°F. indicate that important anaerobic reactions are taking place, and this is confirmed by the appreciable amounts of carbon dioxide evolved under these conditions.

From these results, we can recommend tight, oxygen-free packaging as an adjunct to low temperature whenever there is need to extend storage life. This is particularly pertinent in the case of precooked frozen poultry, such as prefried chicken, in which rate of deterioration is greatly increased over that of the raw product. It should be emphasized, finally, that no statement on storage life can have maximum value and unequivocal meaning unless it accurately defines the package environment as well as the temperature conditions.

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EFFECT OF PRODUCTION FACTORS ON POULTRY FLAVOR

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The studies to be reported were conducted to provide information on the question: Are modern fast-growing broilers as full flavored as those of the period before World War II? The studies therefore encompass age, feed, breed, and management factors. However, these factors have not been singled out in this study. It is to be hoped that at some time it will be possible to evaluate these factors individually and thoroughly.

Three segments of the Department's Agricultural Research Service have cooperated on this research. They are the Poultry Research Branch and the Institute of Home Economics at Beltsville and the Poultry Laboratory at Albany, California. Credit for the work goes to Wade Brant, Helen Hanson, Elsie Dawson, and their associates, including a host of tasters. The only reasonable interpretation of the results is: (1) that modern-type broilers and fryers have not lost flavor compared with older type of birds and (2) that fast growth is not detrimental to flavor, within a reasonable range of variation.

METHODS

Two types of birds were used and two growing conditions. The birds were a slow-growing strain of Barred Plymouth Rocks and a fast-growing, good-fleshing cross of New Hampshire males and Silver Cornish females. The growth conditions were: (1) growth on range on a 1930-type diet and (2) growth in cages on a modern diet. Marked differences in growth rates were obtained. At 9 weeks the faster-growing birds on the modern diet were 60% heavier than the slow-growing birds on the 1930-type diet. When the slow growers were put under modern conditions and vice versa, the rate-of-growth curves were intermediate between these extremes. It was concluded therefore that flavor tests on these birds (and similar birds produced the next year) would help to decide whether flavor has been altered by the major changes that have occurred in the poultry industry during the past 20 years. We are, of course, talking about inherent flavor differences, if any, rather than flavor differences resulting from abandonment of the "New York Dressed" bird.

Over 600 flavor comparisons were made. These included the following old versus modern-type comparisons: (1) equal-weight birds, fried (several separate tests), (2) equal-age birds, fried (several ages), (3) equal-age birds deboned and prepared in equal-size rolls so that cooking times were equal, (4) birds prepared by broiling, (5) birds prepared by microwave cookery, and (6) birds prepared by roasting.

None of these tests showed a significant difference in flavor of the old and modern birds. In 24 individual tests consisting of 30 or more tastings each where panels were asked to designate the bird with the most chicken flavor, the panel average favored the old-type bird 11 times, the new type 9 times, and reported a tie 4 times.

These comparisons of flavor intensity of 1930 and 1956 type birds cooked by 4 methods were made at two laboratories of the U.S. Department of Agriculture under conditions designed to facilitate detection of small flavor differences. Since no differences in flavor of the meat were found at either laboratory in birds cooked by the 4 methods, and since these birds are as nearly representative of their periods as can be produced, my associates conclude, and I concur, that the modern bird has as much "chicken flavor" as the old-style bird. Prompt evisceration of modern birds has probably contributed much more to any flavor differences between modern and old-style broilers than have advances in feeding and breeding methods.

CONCLUSION

The tremendous increase in per capita consumtion of broilers from about 2.5 pounds in 1947 to about 19 pounds in 1957, although due to several factors, indicates that broilers are highly acceptable. The foregoing results lead to the conclusion that modern, more efficient methods of production yield full-flavored birds. Since modernization does not seem to have impaired quality, it is reasonable to attempt still further improvements in efficiency with confidence albeit not without caution. Major new developments that are introduced should be evaluated and tested with respect to their effect on quality as well as on efficiency.

Note: A manuscript describing these results in detail has been submitted to Poultry Science by H. L. Hanson, A. A. Campbell, A. A. Kraft, G. L. Gilpin, and A. M. Harkin.

SOME PHYSIOLOGICAL FACTORS AFFECTING POULTRY FLAVOR

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Our knowledge of the physiological factors influencing the flavor of poultry meat is still in a very primitive state. Much that has been written belongs more properly in the realm of opinion or folk-lore. Only in recent years has experimental work been attempted on meat flavor.

Diet. Much has been written, but little is known, about effects of the bird's diet. In some of the older literature there is no clear distinction among such attributes as texture, juiciness, tenderness, and flavor, all of which are involved in acceptability.

It is often stated that the predominant cereal grain in the ration influences flavor of meat. There does not, however, appear to be any experimental evidence for this statement. Poley and coworkers (14) in a study reported in 1940, found no differences in flavor, aroma, juiciness or tenderness of roasted or fried chickens which had been fed diets in which the principal grain was either corn, barley, or wheat. North (12) reported in 1941 that no differences were found in flavor of turkeys fed rations in which the principal grain was either corn, oats, barley, wheat, or rye.

It would appear that strongly flavored substances in the diet do not necessarily affect flavor. Newman and Schaible (11) have fed, at 20% of the ration, such substances as dehydrated garlic, monosodium glutamate, cloves, sage, allspice, and celery seed and found that only the flavor of garlic was detected in the chicken meat.

A recent report by R. W. Lewis et al. (7) suggests that some ingredients of the ration may have a positive effect on flavor. They found that broth and expressed juice as well as meat from cooked chickens, which had been fed a corn-soybean ration, scored consistently higher in flavor than that from birds fed a purified casein-glucose ration.

Weisberg (18) reported that broth and meat from chickens fed "milk products" was more flavorful than that of unsupplemented birds. This report, however, did not clearly define what was meant by milk products.

Weisberg also cites unpublished data from a thesis of B. L. Lewis (6), which indicated that the flavor of broilers was significantly improved by adding to the diet 10% of dried chicken feces.

It is rather evident that little is known about the positive effects of diet on flavor.

The best known effect of diet on flavor is that obtained by feeding highly unsaturated fats. When fats containing fatty acids with 3 or more double bonds are fed, these fatty acids are deposited in poultry fat in considerable amounts. The fat becomes more unstable, with occurrence of fishy and rancid off flavors. Intense fishiness has been produced in turkeys by feeding 2% fish oil and moderate fishiness by feeding 2% linseed oil. As little as 0.4% fish oil in the diet has been reported to produce off-flavors in turkeys (5).

Other Factors. The opinion has long been expressed in writings on cookery that with increasing age in animals there occurs, along with increased depth of color of the muscles, increased toughness and increased intensity of flavor. High intensity of flavor is therefore supposed to be associated with old tough meat (3, 8).

There is some experimental work on the effect of age on flavor which agrees with statements above. Barbella et al. (1) found that beef flavor increased with age in animals from 11 to 30 months of age and Nelson et al. (10) found a similar result in animals from 8 to 32 months of age. Recent studies at the University of California indicated that meat from 30-month-old steers had greater intensity of flavor than from 18-month-old steers (15).

With regard to the flavor of chickens, Fry et al. (4) reported that baked meat from chickens 14 weeks old or 10 weeks old had more flavor than that of 6-week-old birds. Broth from 6-week-old birds could also be distinguished from that of 10- or 14-week-old birds.

The effect on flavor of estrogen treatment is less clear-cut. Sturkie (16) found no effect of estrogen treatment on flavor of chickens, and Swickard et al. (17) reported that stilbestrol had no effect on flavor of turkeys. Fry et al. (4), however, found differences in flavor of broth from estrogen treated and untreated chickens although no differences were discerned in flavor of baked chickens.

In some of our own experiments (13) we were interested in several extreme treatments which we thought might influence flavor in chickens. In all of these we have used broth prepared from dissected-out muscles to eliminate the distracting effects of texture and other factors. These broths were prepared in a standard manner and submitted to a trained taste panel. Judges were asked to select, from the pair submitted, the sample having the more intense chicken flavor. The following comparisons were made:

1. White Leghorn pullets 13 weeks old versus White Leghorn hens 19 months or older.

2. New Hampshire White Leghorn cross males implanted with stilbestrol at 5 weeks and at 9 weeks of age and slaughtered at 13 weeks. These were compared with an equal number of untreated controls.

3. Same treatment as (2) but given testosterone implants instead of stilbestrol.

4. Same cross and age group as (2) but given intensive exercise by walking in a rotating cage.

Table 1. Effects of various factors on flavor and toughness

Sample	Flavor intensity No. of selections		Toughness Joules/gram	
	Old vs.	Young	Old vs.	Young
Leg[1]	71***	13	21.15***	6.13
Breast	49	35	22.76***	9.85
Total	120***	48	24.95***	7.99
	Leg vs.	Breast	Leg vs.	Breast
Old	70***	14	27.15*	22.76
Young	45	39	6.13	9.85**
Total	115***	53	16.64	16.30
	Stilb. vs.	Control	Stilb. vs.	Control
Leg	23	37	6.41	6.08
Breast	19.5	45.5**	9.60	8.70
Total	42.5	81.5***	8.04	7.38
	Test vs.	Control	Test vs.	Control
Leg	28.5	31.5	5.88	5.54
Breast	36	28	9.64	7.75
Total	64.5	59.5	7.75	6.65
	Exer. vs.	Control	Exer. vs.	Control
Leg	28	26	6.78	6.34
Breast	20.5	39.5*	12.69	10.10
Total	48.5	65.5	10.03	8.38

[1] Leg represents muscle from 2 thighs and 1 leg.

* Significant at 5% level. ** Significant at 1% level. *** Significant at 0.1% level.

The results are shown in Table 1. Toughness of muscle was determined on each sample of cooked meat by the meat-grinder technique of Miyada and Tappel (9). "Leg" refers to both thigh and leg muscle.

Dark muscle of older birds was found to have a more intense flavor than that of younger birds. No significant difference was found with breast muscle in the two age groups, but when the total judgments were compared there was an indication that the muscle of older birds has a more intense flavor than that of younger birds.

Dark muscle of older birds was definitely more flavorful than the light muscle, but no such separation was made with younger birds. However, when all results were totaled, the indication was that dark muscle had more flavor than light muscle.

Stilbestrol treatment tended to decrease flavor intensity, especially in the breast muscle. Testosterone treatment was without effect on flavor.

There was a tendency to ascribe more flavor to breast muscle of control birds when compared with that of exercised birds. It would appear, however, that exercise had little effect on flavor.

The only effect on toughness of muscle was that related to age. Within like kinds of muscle there was no effect of any of the other treatments on toughness.

The principal conclusions appear to be that flavor intensity is increased with age, particularly in dark muscle, but not especially in light muscle. Stilbestrol appears to decrease flavor intensity. It is not possible to conclude that a relationship exists between flavor and toughness.

It is interesting to read the observations of Brillat-Savarin in his book, The Physiology of Taste (2), first published in 1825. He is discussing "osmazome" the essential element of soup stock.

"Osmazome is that pre-eminently sapid part of meat which is soluble in cold water and which differs from the extractive part which is soluble in water that is boiling.

"It is osmazome which gives all their value to good soups. This property is found mainly in mature animals with red flesh or blackish flesh or whatever is meant by well-hung meat. The kind that is almost never found in lambs, suckling pigs, pullets or even in the white meat of the largest fowls. It is for this reason that the lovers of poultry have always preferred the second joint; in them the instinct for flavor came long before science confirmed it."

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EFFECT OF SANITATION, PACKAGING, AND ANTIBIOTICS ON MICROBIAL SPOILAGE OF COMMERCIALLY PROCESSED POULTRY

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The development of micro-organisms is largely responsible for the spoilage of poultry meat. The researches reported here include incidence of bacteria and other micro-organisms that most frequently spoil fresh meat, species generally associated with defects, general plant procedures influencing bacterial populations, and treatments enhancing storage life of fresh poultry meats.

Several methods have been tested for estimating numbers of organisms on skin and lean surfaces. Among these are: pressing of metal dishes filled with solidified agar (spot plates) against the skin, swabbing of known surface areas, use of cut sections of tissue sliced to known depths, smearing of material from the under-wing area on glass slides, and rinsing of birds of uniform size and equivalent amounts of water. For reasons of expediency or reliability the advocates of each procedure claim superiority of one over another. For example, Gunderson and associates (15, 16, 18) used a metal "spot plate" to determine the status of contamination on commercially eviscerated birds. The degree of infection was given a rating of I to VI after comparison with a selected standard. Ziegler, Spencer, and Stadelman (41) developed a rapid microscopic method for bacterial populations. This consisted of uniformly smearing material obtained under the wing on a glass slide, staining, and examining microscopically. These workers reported that observation of slime smear slides prepared in this manner revealed spoilage earlier than was possible by sensory methods. Mallmann et al. (21) claim that shake rinsing provides the most satisfactory index of the organisms on the bird. They sampled half sections of fryers ranging in weight from 404 to 682 grams in amounts of water equal to 1 ml. per gram of weight; the birds were placed in a gallon glass container and shaken mechanically for 2 minutes. In their experience, results with the swab sampling method were too variable. After comparing rinse, cut-section, and swab sampling methods, workers at Iowa State College (4) selected a moist swab procedure because of its ease of use, economy of materials, and rapidity with which it could be used in the processing plant. They cautioned that it was necessary to adopt a standardized technique in swabbing the surface and that a rough mopping with a dry swab often was responsible for some of the variation others had obtained in their results.

Another procedure and one that has been widely used for determining the quality of milk, the resazurin reduction test, was studied (4) to find whether it could be used for determining bacterial quality of poultry. Good correlation was obtained between reduction time and numbers of organisms present on chickens.

There is need for a proper evaluation of the various methods for determining the microbiological quality of dressed poultry. An attempt should be made to find the most desirable procedures for research and for plant use; some of the procedures listed above, such as the cut-section and the rinse methods, do not lend themselves to routine use.

Samplings made by Walker and Ayres (32) in 6 processing plants in Iowa indicated a mean population of 1500 organisms per cm^2 on the skin of live birds and approximately 35,000 per cm^2 on the surface of skin immediately after processing. Gunderson et al. (16) sampled commercially fresh poultry processed in the Omaha area and found that the average initial population for freshly killed, warm eviscerated birds was 4800 per cm^2 while that of birds chilled in ice averaged 60,000 per cm^2. McVicker et al. (22) found approximately 1,000 organisms per $inch^2$ immediately after processing.

Any of a number of microbial species are likely to be found on chicken meat (2, 17, 20) immediately after the bird has been killed and processed.

Chromogenic bacteria accounted for at least half of the total population. Pseudomonas and nonpigmented cocci comprised 1/5 to 1/4 of the flora while the remaining organisms consisted of yeasts and miscellaneous bacteria. The proportion of chromogens and miscellaneous organisms decreased during storage. Ziegler and Stadelman (42) also studied the microflora on poultry and found the predominant types of organisms on fresh birds to be Pseudomonas, Flavobacterium, and yeasts. In another study, Wells et al. (38) reported that at 9° and 12°C. over 50% of the colonies were similar to Flavobacterium.

Within a few days after processing a rather uniform psychrophilic flora predominates and causes development of off odor and slime on the product. Both indications of deterioration were found by Ayres, Ogilvy, and Stewart (2) to be closely associated with growth of coalescence of colonies of several species of Pseudomonas. These organisms reproduced rapidly. At the time of incipient spoilage more than 99% of the total bacteria flora were species of Pseudomonas and Gram negative cocci. A population of about 100 million organisms per cm^2 was considered sufficient for visual manifestation of slime. Relationship of several strains of pseudomonads recovered to species characterized in Bergey's Manual, 6th Ed. (7) was shown by Ayres, Ogilvy, and Stewart (2). The importance of the Gram negative cocci was not determined but was considered of minor importance.

It should be noted that on birds treated with chlortetracycline or oxytetracycline, yeasts comprised a significant proportion of the population. Wells and Stadelman (39) found yeast isolates from treated and untreated birds to be made up of representatives of the genera Rhodotorula, Torulopsis, and

Cryptococcus. The proportions and percentages of various organisms were related somewhat to the temperature of storage. Njoku-Obi and co-workers (25) found Rhodotorula and Torulopsis. They also found species of Saccharomyces, Candida, Geotrichum and several genera of molds. Both pigmented and non-pigmented yeasts were recovered by Walker and Ayres (35) from poultry. The genera they isolated included Rhodotorula, Torulopsis, Trichosporon, and Candida.

Greater numbers of enterococci than coliforms were recovered from fresh chickens. The presence of Salmonellae on chickens and turkeys undergoing processing was studied. The low numbers generally encountered were such that detection was not facilitated by the usual procedure of swabbing only an area 2 to 10 cm^2. For this reason, larger swabs were used and one entire side of the bird was sampled. The quantity of these organisms/cm^2 recovered from turkeys was generally higher than from chicken. With selenite F and tetrathionate as the enrichment broth and brilliant green agar and bismuth sulfite as the streaking media, recovery of Salmonellae ranged from 4 to 15% of the number of turkeys sampled.

Sanitation. The shelf life of pieces of chicken was found to depend upon initial quality. High-, moderate-, and low-count cuts stored at 4° and 10°C. varied markedly in keeping quality. While bacteriological contamination on the live bird contributed to the flora of the eviscerated product, Goresline et al. (14), Drewniak et al. (10), and Walker and Ayres (32) found that sanitary practices adopted in plants had marked influence on numbers of organisms recovered. Bacterial loads were lower in some plants than in others. For example, counts from one plant were 4,000 organisms per cm^2 while from another the load was 350,000 per cm^2. Samplings from visceral cavities ordinarily revealed loads of 1400 to 12,000 per cm^2. Usually, loads recovered from the visceral cavity were lower than those from the skin. However, one processing line--in which crop removal involved flushing the incision with water and where debris as well as blood were washed into the cavity--gave counts ranging from 54,000 to 93,000 per cm^2. Birds were analyzed at various stages along the processing line. Samples were taken from the live bird, the scald water, after the rough picker, after the neck picker, after pinning, after singeing, after evisceration, cavity of bird, the bird as it was placed in the chill tank, fresh chill tank water, aerated chill tank water, and the product after chilling. Counts obtained indicated that the numbers on skin surfaces tended to increase during processing. Usually, numbers of organisms/cm^2 recovered from turkey were higher than from chicken (36).

Temperature greatly influences microbial development and shelf life. Ayres, Ogilvy, and Stewart (2) found that birds at 0°C. had a storage life of 16 days; at 5°C. birds spoiled at 7 days; and at 10°C. off odor and slime were observed at 3 days. Shannon and Stadelman (27) also found that birds kept

considerably longer at 0°C. than at higher temperatures. Baker (5) found no difference in bacterial counts or appearance of dry-packed and ice-packed broilers. However, Stadelman et al. (29) reported that holding chickens in ice for 48 hours prior to cutting resulted in longer shelf life than cutting immediately after cooling. Fromm (13) stated that shelf life of broilers was directly proportional to the time carcasses were held in slush ice.

Ogilvy and Ayres (26) found that atmospheres containing carbon dioxide increased shelf life. The storage index was a linear function of carbon dioxide concentration. Chicken held in an atmosphere containing 15% carbon dioxide kept twice as long as pieces held in air, while those stored in 25% carbon dioxide kept 2.5 times as long. The maximum proportion of carbon dioxide that could be employed generally was considered to be 25%. When higher levels were used, discolorations developed. As carbon dioxide concentrations increased, the effect of temperature was minimized.

Packaging. Packaging was also found to influence bacterial population and shelf life. Stewart (30) discussed some of the requirements, advantages, and limitations of several commonly used films. Carlin, Holl, and Walker (8) reported lower counts for broilers in Cryovac than in LSAD-300 cellophane. Eviscerated chicken in polyethylene at 4°C. usually developed undesirable odor and slime within 6 days. McVicker and associates (22) found that fryers held in loosely packaged polyethylene bags had the same shelf life as unpackaged birds but that fryers in tight-fitting packages with air evacuated had longer shelf life than those loosely packaged. Wells et al. (38) did not consider that cellophane or Cryovac films exerted any direct bacteriostatic effect but stated that partially evacuating air from birds wrapped in impermeable films did tend to inhibit bacterial growth by reduction of oxygen tension. Cotterill (9) reported a fluorescence test wherein, upon exposure to ultraviolet, carcasses packaged in polyethylene, pliofilm, and cellophane gave a positive reaction while those wrapped in Cryovac did not. There may be some question if this test is used as a sole criterion for the superiority of packaging in a tight-fitting film. Since oxygen is required for fluorescence, merely lack of fluorescence does not indicate that spoilage is prevented but only that the Cryovac process eliminates most of the free air.

More work on evaluation of packaging materials and on tests for population changes needs to be undertaken.

Antibiotics. A large number of investigators (1, 3, 5, 6, 11, 19, 22, 23, 27, 28, 29, 31, 37, 40, 42) have studied the practical application of tetracycline antibiotics for delaying microbiological spoilage and thereby lengthening shelf life of poultry meat. Both chlortetracycline and oxytetracycline were found to be equally inhibitory for the bacterial flora at 30 μg/ml. but at lower levels (e.g., 3 μg) CTC delayed growth longer than did OTC or TC. Wells et al. (37) found that

dips containing 10 ppm. of CTC delayed odor and slime more effectively than either of the other two tetracyclines. Data by Vaughn et al. (31) did not differentiate among the three but concluded that TC provided the best overall performance. Treatment of birds by dipping in water containing any of the tetracycline antibiotics was shown to produce two separate effects: it reduced the total flora, thereby prolonging the storage life when used once only, and when used continuously in the same equipment over an extended period, larger proportions of the populations consisted of Pseudomonas and yeasts.

Chlortetracycline (CTC) had little if any inhibitory effect on growth of Pseudomonas or yeasts; at the time that off odor and slime developed, these organisms comprised at least 95% of the population. Yacowitz et al. (40) were among the first to report that there was increased yeast growth and yeasty odor from chicken parts treated with CTC. Ng et al. (24) observed that resistant forms of bacteria prevailed on birds processed in the presence of CTC. Also, in trials conducted by Walker and Ayres (32), organisms found on poultry treated with CTC, OTC, or TC were observed not to be as susceptible to these antibiotics as were the bacteria on control birds. Organisms found to be resistant to one of the tetracyclines were also resistant to the other two. Among these, the pseudomonads and yeasts were the most numerous and had the most significance to spoilage later. Growth of Pseudomonas fluorescens and of yeast isolates in mixed culture showed that the maximum number of yeasts was not as high as when the yeasts were growing in the absence of bacteria. When CTC was added to a mixture of organisms, the number of yeasts was equal to that found in the control (yeast only). The presence of yeast had no apparent effect upon growth of bacteria. Addition of CTC to a mixture of yeasts and pseudomonads or pseudomonads alone caused a lag in the growth of bacteria. It would appear that the increased numbers of yeasts on antibiotic-treated poultry can be explained primarily on the basis of decreased numbers of bacteria which otherwise suppress the growth of yeasts.

Recognizing the limitations that use of antibiotic treatment had against pseudomonads and yeasts when CTC was used alone, Ayres et al. (3) used combinations of CTC with various other agents such as streptomycin, neomycin, nystatin, aerosporin, myprozine, ascosin, and rimocidin. CTC used with neomycin or nystatin was effective in reducing populations of Pseudomonas. When used in combination with myprozine , complementary action retarded both bacteria and fungi. Tetracycline residuals recovered from the skin of antibiotic-treated chicken meat were found to decrease rapidly during the first 48 hours. After that, however, the concentrations were much more constant and detectable amounts could be found for at least 21 days. Losses in the deep tissue were much less pronounced and, in all trials,

persisted at higher levels than on the surface. No preferential absorption of the antibiotic appeared. The levels that persisted depended upon concentration of antibiotic and upon time of exposure to the antibiotic.

It is probably safe to assume that the amount of CTC residue permitted in raw chicken (7 ppm.) is sufficiently low that the chemical is not active after cooking. However, with red meats receiving much less drastic cookery (frankfurters and ground meat patties) Escanilla et al. (12) found that this was not true. Ground meat patties cooked to 71°C. (well done) still had residual CTC; the amount of active tetracycline remaining was a direct function of initial concentration in the raw ground meat. They concluded that, regardless of level of CTC used, the antibiotic was not completely inactivated.

Recently, Meyer et al. (23) reported that agar and carregeenin gels increased the keeping time of eviscerated poultry when the tetracycline antibiotics were incorporated in the coatings and also that combinations of these with other antibiotics were more effective than were the tetracyclines alone.

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USE OF HIGH ENERGY RADIATION TO "PASTEURIZE" POULTRY

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The shelf life of poultry has been shown to be significantly extended by relatively low doses of high-energy radiation. Such radiation does cause unimportant (apparently) changes in flavor. Because the changes are less, or are less objectionable, for poultry than other meats, a number of institutions have worked with poultry. Perhaps the most thorough work on pasteurization has been conducted at the Low Temperature Research Station in England. However, Massachusetts Institute of Technology, Oregon State, University of Illinois, and Michigan State University have reported pasteurization studies also.

The potential for commercial adoption of radiation treatments of food is still being approached with "cautious optimism" by many workers on both sides of the Atlantic.

B. Coleby summarized the British work on poultry pasteurization as follows:

"Odour changes in raw minced chicken meat could be detected with doses as low as 50,000 rads, but if such samples were afterwards cooked by steaming most people could only detect adverse flavour changes if the meat had been given doses of 250,000 rads. Whole chicken carcasses responded rather better; after doses of 500,000 rads or more, flavour changes were only just detectable in the roasted birds. Margaret J. Thornley said that bacterial counts on the minced chicken irradiated with 250,000 rads showed that it could be stored at 5°C. several times longer than unirradiated control samples; lower doses produced only a slight increase in storage life. Whole chicken carcasses, packed in 'Polythene' bags and given 500,000 rads, could be stored at 3°C. for two to three times as long as control samples. The bacterial flora of irradiated chicken differed considerably from that normally observed. M. Ingram emphasized that selective elimination of some micro-organisms by irradiation could result in the eventual spoilage of the chicken taking an unusual course. Adequate refrigeration seems essential to prevent the growth of possibly harmful bacteria which might survive irradiation."

Radiation and antibiotic treatments have been shown to be supplemental by Cain et al. for beef, since the sensitivities of micro-organisms to these agents are not parallel. Dual processing would of course increase costs. Sterilizing doses of radiation inactivate the tetracyclines essentially completely.

McGill et al. reported that radiation sensitized poultry to rancidification and, curiously, that the temperature coefficient of this induced rancidification is negative.

Conclusions

Shelf life measured by microbial inhibition can be extended considerably. The spoilage pattern is altered and could be more hazardous than normal spoilage. Inert gas packing would probably be required to control rancidity. Antibiotics can supplement radiation. Neither, of course, is a substitute for sanitation.

Safety. Extensive toxicity and nutritional studies make it appear thus far that no danger exists from chemical changes induced by pasteurization doses. Potential but undemonstrated danger due to growth of pathogens resulting from accidental exposure to temperatures above 5°C. is considered to exist.

Acceptability. A half to 1 megarad, which is a pasteurizing dose, causes changes in flavor of cooked poultry that expert tasters can detect. The odor of uncooked birds is considered objectionable. The color of cooked birds (pinkness) is possibly objectionable.

Costs. It is generally considered that a pasteurizing dose would cost only a few tenths of a cent per pound for machine-produced beta rays. At present the cost for gamma rays would be significantly higher. These costs do not include product handling charges but do include radiation power, equipment, operation, and overhead.

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FACTORS PROTECTING EGGS FROM BACTERIAL SPOILAGE

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The studies I shall describe are concerned with factors that protect the egg from microbial spoilage. An understanding of these factors would enable more adequate control of shell egg contamination and of the problems which spoiled eggs present in the preparation of frozen and dried egg products.

Although the shell restricts the entry of micro-organisms to some extent, the egg membranes present the bacteria with a more serious obstacle. Several days are usually necessary for bacteria to overcome this barrier. The mechanical nature of this protective action was indicated by the finding that all bacteria tested, which included 27 strains of 8 genera, were able eventually to penetrate shell membranes without significant decomposition of membrane material (1).

After breaching these barriers micro-organisms reach the white, which inhibits growth through action of such factors as lysozyme, avidin, high pH, conalbumin and ovomucoid (2). Gram-negative egg spoilage bacteria are not affected by lysozyme or avidin. Ovomucoid had no effect on rate or extent of bacterial growth. Conalbumin is the controlling factor in preventing growth of gram-negative bacteria in egg white, as indicated by the following evidence: When strains isolated from spoiled eggs were inoculated into white at pH 9.2, only 10% of the strains tested attained populations in excess of 10^5 per ml. Adjustment of pH to 7.0 allowed many additional strains to grow. That pH, *per se*, was not the inhibitory factor was shown by reversal of this inhibition by iron.

All bacterial strains grew extensively at pH's more alkaline than those found in the white of stored eggs when iron was added to the white in excess of that necessary to saturate the conalbumin. Some strains grew when the conalbumin was 5% saturated with respect to iron and others grew at 30% saturation. Bacterial strains therefore must differ in ability to obtain iron from the iron-conalbumin chelate. Increasing the acidity of the egg white reverses the inhibition by dissociating the chelate (3), thus making iron available to the bacteria.

All bacterial strains grew readily in egg yolk. Investigations now in progress are concerned with site of development of the egg spoilage organisms in shell eggs. Of academic interest would be the study of mechanisms by which micro-organisms are able to utilize iron in the presence of excess conalbumin.

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CLASSIFICATION OF MICROORGANISMS FROM SPOILED CHILLED POULTRY

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Ayres et al. (1950), reporting on organisms associated with slime on poultry, stated that Pseudomonas and Alcaligenes were repeatedly isolated and members of the former genus were more commonly encountered. They stated that Pseudomonas and to some extent Gram-negative cocci or coccobacilli (presumably Alcaligenes or Achromobacter) were present exclusively at the end of the storage period. Yeasts have been shown to be common on spoiled poultry treated with the tetracycline antibiotics (Ziegler and Stadelman, 1955; Wells and Stadelman, 1958; Njoku-Obi et al., 1957). However, Ayres et al. (1956) and Simpson et al. (1959) have demonstrated that yeasts are not important in spoilage of commercially processed poultry.

This is a report from a survey of spoilage populations on fryers purchased from retail markets in the Sacramento area.

The 103 isolates classified were distributed generically as follows: 88 Pseudomonas, 2 Aeromonas, and 13 Achromobacter or Alcaligenes types. Only 4 cultures were capable of growing at 37 °C. (2 Aeromonas, 1 Pseudomonas, and 1 Alcaligenes). All but 2 of the Pseudomonas strains were resistant to penicillin (10 units), while 11 of the 13 Achromobacter-Alcaligenes bacteria were sensitive. No significant correlation between sensitivity to terramycin and the non-pigmented Pseudomonas isolates could be demonstrated. The kinds of organisms found on tray-packed poultry were not influenced by geographical location of the processing plant or by antibiotic treatment. In addition, the distribution of genera was not altered regardless of whether the fryers were tray packed at the processing plant or store.

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PSYCHROPHILES

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Bacteria are generally divided into thermophiles, mesophiles, and psychrophiles on the basis of the temperature range in which they can grow. The first two groups can be easily and accurately characterized and distinguished by their growth-temperature optima. The psychrophiles have also been defined, especially in textbooks, in terms of optimum growth temperature. But the latter has been set either so low that it fits virtually no known bacteria or so close to that of mesophiles that it fails to separate the two groups.

There is in nature, however, an important and distinct group of bacteria which differs from thermophiles and mesophiles not so much in optimum growth temperature but rather in its ability to grow at low temperatures, at or close to 0°C. These low-temperature bacteria are commonly called psychrophiles. This is a misnomer because it implies that these bacteria are "cold-loving". Actually, although these bacteria grow relatively rapidly and extensively at freezing temperatures, they develop much more rapidly at higher temperatures and the optimum growth temperature may be as high as 30° to 40°C, or even higher. They are cold-tolerant. In any event, psychrophiles are widely distributed in nature. They occur in large numbers in soil, water, foods and other habitats where they carry out important beneficial or harmful transformations at temperatures which are too low for the growth of other types of bacteria.

Psychrophiles are important spoilage organisms of chilled poultry. They develop fairly rapidly at 4°C. and can produce populations of many millions of cells on the exposed chicken surfaces within a week. This results in sliminess and in formation of undesirable off-odors and off-flavors. There are also psychrophilic yeasts and molds which may develop. All of the available evidence indicates that the minimum temperature for the growth of psychrophilic micro-organisms is -10°C. Therefore for full protection of foods from the deleterious effects of microbial growth, they must be stored at temperatures below -10°C.

Note: A review covering in considerable detail information available on psychrophiles will appear soon in Bacteriological Reviews by J. L. Ingraham and J. L. Stokes.

INFLUENCE OF INHERITANCE AND AGE OF HEN UPON INITIAL EGG QUALITY

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Evidence is reviewed showing that our genetic knowledge about many characteristics of egg quality has not yet developed to satisfactory levels. On the other hand, other characters have been extensively studied and the information at hand is reliable and effective in the hands of the breeder.

Egg weight inheritance is generally considered to be polyfactorial. Heritability is high and continuous selection in mass matings suffices to maintain a satisfactory size of market egg. Egg shape is characteristic of individual hens and marked progress in achieving the desired ovoid shape of eggs can be made within two generations.

Shell color, thickness and smoothness are heritable and selections can improve characteristics. A white-egg strain can be maintained only by vigorous selection in each generation. Genetic studies have not been made of shell porosity or shell membrane thickness or pigmentation.

Albumen quality seems definitely to be a multiple-factor inheritance characteristic.

Yolk, of all egg structures, seems to be the least influenced by hereditary factors.

Bloodspotting is not highly heritable. However, differences exist between breeds and lines of the same breed and a selection program can readily yield a line with a very high incidence of the defect.

Meat spotting heritability is not high. This trait is determined by different genes than blood spotting, as expected, since the two types of spots have been shown to be of different origin.

Compositional differences between eggs from various breeds or strains have been noted for vitamins A, thiamine and riboflavin and for lysozyme.

Age of hen appears to affect several egg characteristics. Size, dry matter of contents and shell porosity increase with age of hen, while albumen quality declines as does percentage of shell and shell thickness. Flavor seems unaffected by age.

Note: The full text of this talk including 80 references has been submitted to Poultry Science for publication.

SOME FACTORS AFFECTING THE PRODUCTION AND MARKETING OF EGGS IN THE MID-WEST

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The purpose of this discussion is to point out some factors in the current production and marketing of eggs in the Mid-West.

There are, of course, large variations within the egg industry in the Mid-West. The major table-egg surplus-producing area is located in northern Iowa and southern Minnesota. Large quantities of shell eggs from this area are shipped to markets outside the region, as well as to deficient areas within. Other areas of surplus production exist, for example in Kansas and Nebraska, but a large portion of these eggs are channeled into the liquid, frozen, and egg solids market. These areas might be referred to as semi-surplus; that is, a surplus exists in total supply with respect to population but local markets are provided through breakers. Also, there are areas where the total supply would essentially balance the local need for table eggs except that a large volume of these locally produced eggs are broken. The net effect has been the creation of a shell egg (table use) production and marketing scheme more like that of deficit areas. This type of situation existed in Missouri during the past year. Finally, of course, there are the true deficit areas, like Ohio, where egg supply does not meet local demand, which is almost exclusively a shell egg trade. The volume of Ohio eggs destined for the liquid, frozen, or egg solids trade is nil compared with the quantity of eggs produced. No one condition describes the Mid-West egg production and marketing situation. With respect to flock size and market programs, there are all degrees of evolution within the Mid-West area.

The competitive position of the Mid-West in relation to other regional areas is the subject of many discussions. It seems that each region or perhaps each state is attempting to become self-sufficient regarding egg supply; then in addition, they plan to export their surpluses to other areas which are already self-sufficient. Although the West North Central states have a surplus, the percent of total U.S. supply produced in this area is declining. However, the competitive advantage gained in recent years by some areas has developed as a result of the employment of highly efficient production and marketing practices. Only in recent years has the Mid-West adopted some of these more efficient practices. There is still room for improvement. Some possibilities are listed below:

I. Production Costs: (A) Increase flock size. (B) Reduce housing cost. (C) Potentially, feed cost can be reduced. (D) Labor efficiency. (E) Sharing of risk.

II. Quality and Uniformity of Product: (A) Lag between research and adoption of new practices. (B) Organized production-market programs.

III. Procurement and Distribution Costs: (A)Reduce intermediate handlers. (B) Concentration of product (liquid, frozen, dried). (C) expand egg product usage.

The subject of organized production-market programs (integration) has been well popularized. There are various reasons for their development. They are being organized to meet local egg supply needs, export needs (to other regions), and to meet the needs of egg processors (liquid, frozen, and dried). There are various reasons for the organization of these programs, for example: (A) Improve quality. (B) Obtain product uniformity. (C) Obtain necessary volume of eggs. (D) Obtain uniform supply throughout the year. (E) Specific outlets (table egg vs. breaking stock).

Procurement of eggs for the breaking industry in the Mid-West is involved in some degree of evolution at present. This condition is particularly evident in Missouri. One-Fourth of all eggs broken in the U. S. are processed by Missouri plants. There are 27 breaking plants and 9 drying plants located in this state. Several of the drying plants have more than one type of dryer as well as different drying operations. During the past year, they have been faced with a shortage of eggs. Also, there has been a tendency toward year-round operation of breaking plants. There are various reasons for this development, as follows:

Seasonal Surplus. The development of a more uniform year-round production of eggs has greatly decreased the spring surplus. Production per hen has increased, particularly in the late summer and fall months. Pullets are started at different times of the year. Not only has the surplus spring production decreased but the price differential between spring and fall is less, making it even less desirable for the breaker to operate on seasonal basis.

Mid-West Surplus Production Declining. Because of decreased numbers of small farm flocks which have been the primary source of breaking stock, this supply of eggs to breakers is decreasing. Many of these eggs were obtained on a current receipt basis.

Shell Egg Contracting Increasing. More eggs for table use are being produced under contract, which means that few if any of these eggs enter breaking channels. In other words, they are produced for a specific market and are rarely available to breakers.

Quality of Residual is Poor. The enactment of new egg laws in the Mid-West has encouraged more topping of eggs for quality markets; the remaining raw material is much less desirable for breaking stock. This residual would tend to require more labor for breaking, have higher bacterial counts, yield an egg yolk with lower solids content, and a white with poorer inherent functional properties.

Fixed Plant Cost. A plant operating seasonally has to be larger than one producing the same volume on a year-round basis. There are many additional overhead costs with such an operation. Previously the wide price differential between spring and fall eggs made it possible to operate under these conditions.

Storage Cost. These costs have been increasing and in the absence of large seasonal price differential, it is more imperative that long periods of storage be avoided. Several companies operating breaking plants in the Mid-West have shown an interest in contractual arrangements for their egg supply. This interest varies with supply of eggs available at any given time in the area. One pilot scale program is presently in effect in Missouri. It is certain that these programs must be flexible; otherwise, there are times when certain disadvantages will overshadow some advantages.

EGG PRODUCTS: QUALITY AND DEVELOPMENT TRENDS

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According to available statistics, about 7.5% of eggs presently consumed are going into egg products. This portion consists of about 1.5% as dried and 6.0% as liquid and frozen and represents a total annual volume of 480 million pounds on a liquid basis.

Between 1939 and the present, not including war and price support years, the percentage of total raw liquid separated which has gone into drying has increased from 15 to 27% (salt products excluded). This increase reflects principally the great strides made by dried egg white which for most purposes is competitive with frozen whites and to a lesser extent improvements in "whole egg" products. On the other hand, the percentage of yolk which goes into drying has decreased slightly in the same period. It is believed that improved percentage utilization of "whole egg" in the dried form is actually chiefly attributable to development and increased acceptance of certain proprietary products as fortified whole egg, fortified whole egg with stabilizer solids, and sugar whole egg.

The much greater development of dried albumen as compared to dried yolk-containing products serves as an indication of quality deficiencies still prominent in the latter. These include problems in dispersibility, performance value, and flavor stability (in air). Research on these problems was initiated a few years ago at this Laboratory and some promising leads have been obtained. Thus, dispersibility of yolk-containing solids, which are presently spray-dried, may be markedly improved by forced-air drying of mechanically formed foams. Performance value for bakery usage may be improved by addition of various carbohydrates before spray-drying. Use of sucrose, however, intensifies the flavor stability problem. Flavor stability generally may be improved by use of several antioxidants or by means of feasible inert-gas packaging as in foil laminates. Perhaps the most striking improvement in flavor stability, however, has been achieved where certain corn sirup solids are substituted for sucrose, resulting in powders that combine good functionality with flavor stability.

Although no health hazards in actual usage have been clearly related to occurence of Salmonella in egg albumen, occasional scare-type statements have been made about the potential problem. One possible solution being investigated here is use of ultraviolet radiation on egg white exposed in a thin film

in a centrifugal bowl. Kills of up to 10^6 Salmonella typhimurium per ml. in otherwise sterile egg white have been achieved but not without detectable, though slight, off-flavor development.

Probably the most critical utilization problem in the egg product area is represented by the continued surplus of frozen and dried egg white. This appears to be a stable situation which will not be resolved without development of new outlets for egg white.

There is a continued trend in procurement of eggs for egg breaking in which the egg breaker may have control over production and handling of his raw material. This developing situation makes it useful to study the relation of shell egg history (breed and age of layer, treatment, and handling conditions) to the ultimate egg product quality.

OBSERVATIONS AND QUESTIONS ON TABLE EGG QUALITY: PROBLEMS ON THE PACIFIC COAST

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Egg marketing on the Pacific Coast is featured by sales of AA as the predominant grade. Examination of the break-out quality of such eggs (large AA) picked up in retail stores over a 2-year period revealed the large majority (75%) to average about 59 Haugh units with the spread indicated by a standard deviation of about 15. Exceptions were individual distributors who would consistently market, on one hand, eggs averaging 50 H. U. and on the other, eggs averaging 68 to 70 H. U. One distributor achieved the latter by combining a compulsory replacement program with refrigeration from ranch to store. A second distributor achieved the same high (68 to 70) mean H. U. at the retail store point without a compulsory replacement program but combined processing at the farm on day of lay (emulsion spray) with refrigeration from ranch to store. A third distributor, in an experimental program, is achieving 70 to 75 H. U. at the store level by using a complete oil dip after holding the eggs on the ranch at 50° F. overnight.

Use of either partial or complete oiling on the ranch has unquestionably given rise to certain defects, in particular cloudy whites, curdly or "buttermilk" whites in soft-boiled eggs, and hard-to-peel hard-boiled eggs. The hard-to-peel defect is considered to be the principal one limiting the usefulness of such farm processing. This defect is characterized by considerable white peeling off with the shell (up to 30% as compared to a norm of 10. 5%), length of time required to peel (1 to 4 minutes vs. 10 to 15 seconds for the norm) and the mushy appearance of the residual white instead of the usual rubbery and shiny surface observed. While use of a partial seal (emulsion spray) on day or lay yielded 10 to 13 additional H. U. in the usual marketing channel (10 to 2 weeks from day of lay) roughly half of such eggs would be anticipated to exhibit the peeling difficulty. Available statistics indicate that 13 to 14% of eggs are eaten as hard-boiled which would, in the above case, indicate that difficulty would actually be experienced with 6 to 7% of the eggs.

The peeling difficulty was found to be correlated with the pH of the white; it disappeared at about pH 8. 9 in the case of eggs hard boiled starting with cool or warm water and at about pH 8. 6 for eggs placed directly into boiling water. Pre-soaks or cooking in various alkalis, in an attempt to raise the pH of the outer white, were ineffective with the exception of dilute ammonia, in which case other objectionable characteristics developed.

Studies were made to determine whether delayed oiling (that is, permitting pH of the white to rise) would offer any combination of conditions where oiling effectiveness and minimum peeling difficulty could be achieved. Eggs were oil dipped after holding intervals at both 34° and 55°F. and subsequent storage was at 55°F. in both cases. Results consistently indicated that complete oiling at pH's of the white 8.4 and below would reduce the H.U. drop during 2 to 3 weeks at 55°F. by 65 to 80% while oiling at pH's 8.5 and above a sharp decrease in extent of protection to 20 to 30% was observed. In our studies, the whites of eggs held overnight at 55° reached a pH of 8.4 to 8.5. Combined with the above observations, this would minimize the value of oiling or partial oiling at this point or later in view of the anticipated peeling difficulty.

Taking into account initial H.U. quality observed on the Pacific Coast (75 to 86 H.U. flock average on day of lay), possible improvements in initial quality by means of breed selection and a replacement program, and observed rates of H.U. decay (at 55° initial decay about 3 to 4 H.U. per day tapering off to about 0.5 H.U. per day with overall average for a 2-week period about 1.25 H.U. per day), about 66 to 70 H.U. average at the consumer pick-up point is about all that can be reasonably expected in a 10-day to 2-week (at 55°F.) marketing channel. Of course, farm processing, in particular partial sealing by means of emulsion spray or dip, aerosol cans, or mist oilers, offers an attractive way of increasing internal quality further or even obviating need for a compulsory replacement program. However, until a method is found for partial sealing which is reproducible at the farm level, compatible with minimizing bacterial invasion and correlating the degree of sealing with marketing time, peeling and other cooking and appearance defects will accompany use of this method.

EGG QUALITY PRESERVATION IN THE MID-WEST: CLEANING, REFRIGERATION, RAPID HANDLING

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Few problems related to poultry have been the subject of more discussion, more argument, more research, or more writing than have the problems of egg quality in recent years. "Egg quality" has been defined in many terms, from the standpoint of the producer, from the standpoint of consumers, and from the standpoint of grading officials or programs. In the final analysis, most definitions are essentially the same, and refer to the degree of excellence of an egg, a dozen eggs or a case of eggs, for human food.

We are all aware of the important contributions of the geneticists, nutritionists, health specialists, and all others who have been instrumental in supplying birds which lay more eggs, more efficiently, and with inherent good quality.

Once eggs of good quality are produced, it is the responsibility of producers, handlers and retailers to do everything possible to maintain that inherent goodness for our vast consuming public, and this responsibility is almost always linked with the economic term - profit.

The Mid-West has frequently been termed the egg basket of the United States. The 12 states in the North Central Region produce 47% of the nation's egg supply (1957) and many of these eggs travel long distances to consuming markets. It is extremely important that proper care and handling be excercised at all times.

To bring you an accurate picture of the egg business, a survey was made of the 12 North Central states to find out exactly what is being done to market better quality eggs. Questions regarding egg cleaning practices, egg processing practices and other handling procedures were asked. Dr. Swanson will discuss shell treatments so I will confine my remarks to other practices in handling eggs.

Egg Cleaning Procedures. One of the most prevalent practices is that of washing eggs--with considerable controversy among researchers. This is not a practice designed to preserve quality but rather to increase usage, because producers receive more money for clean eggs and washing is more efficient (labor standpoint) than dry cleaning. Since we receive many complaints about "sour" eggs and other eggs with "off-odors", some of which are attributed to washing, we feel it is a practice closely related to quality preservation.

The survey mentioned earlier indicated the extent of egg washing to be as follows: In 3 of the 12 states, between 75 and 100% of eggs were immersion washed. In 5 states, between 50 and 75% were immersion washed. In 1 state, between 25 and 50% were immersion washed. In only 2 states, less than 25% were immersion washed. Ten states reported that this practice is increasing and only 1 state reported a decrease in this practice. Few eggs are cleaned by sanding, since 7 states reported less than 5% of eggs sanded and no state reported more than 15% of eggs cleaned in this manner.

Egg Coolers Increasing. One of the most significant trends affecting preservation of egg quality is the increase in emphasis on controlling temperature and humidity in egg rooms by refrigeration. Eight states reported that temperature and humidity control was the most important single factor in maintaining egg quality. Egg buyers as well as Extension personnel are stressing more and more the need for adequate holding facilities for high-quality eggs.

Complete Programs--Integration Increasing. Three states reported that integrated programs, in which quality control was an essential part of the program, were most important. Speaking specifically for Michigan, we have at present several of these so-called integrated programs developing. The Farm Bureau is reportedly ready to supply a very substantial sum of money to develop such a program in which the minimum flock will be 1,000 layers per farm to start with, and probably several thousand per farm after the program is under way. Other programs are under way in which a minimum of 100,000 layers per area are developing. All of these programs have one or more of the following rigidly enforced: specified breeding, specified feeds, controlled housing and ventilation, controlled feeding and watering systems, controlled temperature and humidity in egg rooms, controlled cleaning of eggs, and controlled delivery of eggs to the first receiver. Some of these programs are also incorporating a practice of oil processing for their eggs.

One of our oldest and largest egg associations has recently inaugurated an "egg premium agreement" with its producers. To remain on this program, the producer must: (1) Market 95% of all chicken eggs to the association. (2) Deliver eggs at least twice per week. (3) Use Association feed. (4) Have a minimum of 80% grade A eggs. (5) Produce infertile eggs. (6) Deliver clean eggs. (7) Have less than 1% blood spots by candling.

This is a new program and purchase of eggs on a broken-out quality basis is already being considered. The general trends in the North Central Region can be summarized as follows: larger production units, washing more eggs at farm level, increasing use of refrigeration on farms, increase of integrated programs, and increased adoption of "egg premium contracts".

SHELL EGG PRESERVATION IN THE MIDWEST: PROGRESS IN SHELL TREATMENTS

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The Mid-West, especially the states in the West North Central group, is an egg surplus producing area which must ship considerable distances to terminal markets. Consequently, to compete on a quality basis, this region must take advantage of every practice available for the preservation of egg quality in market channels. For this reason it was natural that the Mid-West should be one of the first to give on-the-farm shell processing of eggs a thorough test.

In a recent survey of the entire North Central Region (11 states responding), 2 states indicated that about 10% of their eggs were oil treated at the farm, 7 reported that 1 to 5% of their eggs were so treated, and 2 said there was little or no shell treatment at the farm level. In answer to a question regarding the trend of this practice, 6 states said it was increasing, 2 indicated interest only, 2 reported no interest, and one saw no trend. The majority of the states in this survey reporting considerable activity in oil processing, both at the farm and at receiving stations, were members of the West North Central group.

The rate at which shell treating by the producer increases in the Mid-West will largely depend on the growth and success of quality egg programs now being promoted by chain-store organizations, egg assemblers, feed companies, and others. Unless the individual producer is a part of one of these programs, he has little incentive to oil-process his eggs because with twice a week delivery plus some effort to properly cool the eggs, there will be little difference in candled grade between treated and untreated eggs at the first receiver. The real benefit derived from on-the-farm oiling is best recognized at the consumer end of the market channel.

Additional research is needed to answer a number of questions raised by industry in connection with shell treating eggs. One of these is concerned with optimum quantity of oil to apply. In Minnesota tests 3 to 4 grams of oil were required per 30- or 36-egg flat to obtain maximum protection under severe holding conditions (75° for 10 Days). Less than half this quantity proved adequate with refrigeration. Method of application is probably of less importance than quantity of sealer applied.

Are there possibilities of modifying conventional egg-processing oils or even substituting completely new products in order to increase the efficiency of the shell treating process? Improvements in the sealing quality, spreading property, and final appearance given the egg by the oil are within reach through more research.

The difficulty encountered in the peeling of eggs that are oil-processed shortly after laying is a problem meriting immediate attention. We have evidence that pH of the albumen plays an important role and that above pH 8.6 to 8.7, little or no trouble is experienced. The pH of the albumen can be easily changed through exposure of shell eggs to ammonium hydroxide fumes or carbon dioxide.

The need for farm refrigeration when eggs are oiled shortly after laying is often questioned. Both oiled and unoiled eggs benefit about equally from proper refrigeration for the first 4 days after laying as measured by break-out quality after 10 more days of refrigerated holding. Oil treating per se may be of actual greater benefit than refrigeration, but refrigeration and shell treating can very properly supplement one another to deliver a better quality egg to the consumer than can be done with either practice alone.

EGG PROTEINS

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The egg proteins are of great interest to individuals working in many fields. They include embryologists, food technologists and fundamental protein biochemists, as well as those with perhaps a less direct interest such as bacteriologists and virologists. Many of the egg proteins have been highly purified and are presently used as "standard" or "reference" proteins and as tools for the study of the fundamental properties of proteins.

The most recent general and detailed review is that of Warner (1954). Specific consideration of the egg white proteins is given in an article by Rhodes, Azari, and Feeney (1958) describing the analysis and fractionation of egg white. Joubert and Cook (1958) have considered the complexity of the lipoproteins and their interrelationships with the phosvitin of egg yolk. Tables 1 and 2 contain an approximation of the composition of egg yolk and egg white. Obviously, our knowledge of the egg proteins is still incomplete.

Table 1. Composition of Egg White[1/]

Constituent	Approx. amount, %	Approx. I.P.[2/]	Unique properties
Ovalbumin	54	4.6	Denatures easily, has sulfhydryls
Conalbumin	13	6.0	Complexes iron, antimicrobial
Ovomucoid	11	4.3	Inhibits enzyme trypsin
Lysozyme	3.5	10.7	Enzyme for polysaccharides, antimicrobial
Ovomucin	1.5	?	Viscous, high sialic acid, reacts with viruses
Flavoprotein-apoprotein	0.8	4.1	Binds riboflavin
"Proteinase inhibitor"	0.1	5.2	Inhibits enzyme (bacterial proteinase)
Avidin	0.05	9.5	Binds biotin, antimicrobial
Unidentified proteins	8	5.5, 7.5 8.0, 9.0	Mainly globulins
Non-protein	8	--	Primarily half glucose and salts (poorly characterized)

1/ On a dry weight basis. Egg white usually contains 10 to 12% solids.

2/ Approximate isoelectric point. These are actually averages because all egg-white proteins so far carefully examined appear to be microheterogeneous (Feeney and Rhodes, 1958). For example, 3 ovomucoid fractions with slightly different isoelectric points have been obtained.

Table 2
Composition of Egg Yolk[1/]

Constituent	Approx. amount, %	Particular properties
Fats		
Neut ral glycerides	42	Acids vary with diet
Phospholipids	20[2/]	Primarily 3/4 lecithin and 1/4 cephalin
Sterols	2	Primarily cholestrol
(Total fat)	(64)	
Proteins		
Livetin	5	Contains enzymes--poorly characterized
Phosvitin	7	Contains 10% phosphorus
Lipoproteins	21[2/]	Emulsifiers
(Total protein)	(33)	
Other		
Primarily sugar & salt	3	

1/ On dry weight basis. Egg yolk contains approximately 50% solids.
2/ Approximately one-third of the phospholipid is bound in the lipoproteins.

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STATUS OF EGG LIPOPROTEINS

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The subject of egg lipids is too broad to permit presentation of a comprehensive picture in a short period. Therefore, no attempt will be made to present data which have been a part of the literature for a long period. Rather than make such a review, I shall attempt to review some of the recent literature related to those substances present in egg yolk which are considered to be high in lipid, to point out some of the difficulties involved in investigating these substances, and to indicate recent trends in the study of these substances in our own and other laboratories.

A review of the literature reveals that, in general, considerable confusion has resulted from the fact that many workers have employed methods of separation and purification which most investigators consider to be detrimental to the stability of large protein-lipid complexes. Many workers have failed to indicate or control pH and temperature, and, in general, have roughed up the complex molecules so that it is not possible to correlate the resulting component with a material in the original substance. This is not a criticism of previous investigators but part of the history of the investigation of any complex material.

Recent work in England, Canada, and in our own country has recognized these difficulties and investigators are attempting to re-examine the problem of yolk lipoproteins. For example, Lea and co-workers in England have shown recently that the stability of the known yolk lipoprotein complexes is extremely sensitive to pH and physical treatment. This work casts a new light on the type of separation employed and may well lead to a re-examination of previous separation procedures. Cook and co-workers in Canada have finally concluded that the lipoproteins prepared by ether extraction are apparently fragments of a lipid-protein complex having a higher lipid content. These workers have made a recent attempt to eliminate ether from their fractionation procedures. Schmidt and co-workers in this country have published a preliminary separation of yolk constituents based on use of a supercentrifuge but have employed room temperature. In our case ether was employed in the early work, but during the past 2 years we have excluded ether from our procedures and have employed ultracentrifuge and electrophoretic techniques to attmpet our separations.

In general the English investigators, led by Lea, have concentrated on the analysis of the lipid portion of the lipoproteins. The Canadian workers, led by Cook, have been determining the physical-chemical characteristics of known yolk preparations, and recently have made an attempt to exclude organic solvents. In our laboratory, we have been ignoring properties and chemical

composition and concentrating on preparing fractions of lipid containing proteins which we hope will be pure enough to characterize, and after this separation has been accomplished we will attempt as much of chemical and physical-chemical characterization as possible.

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FLAVOR CONSTITUENTS

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Work reported in 1954 by E. L. Pippen and associates showed that chicken broth scored high and that fat separated from chicken broth scored very low in flavor intensity. They found, too, that flavor of broth prepared from chicken meat which had been stripped of fat by ether extraction did not differ significantly from unextracted broth. However, on the basis of odor, there was a highly significant difference between extracted and unextracted broth. They suggested further work on the role of fat.

This is a preliminary report of studies on the role of fat and other fractions from meat in the development of the flavor that characterizes the product. Statistical analysis has not been completed and firm conclusions should not be drawn from these data. They are shown to indicate the direction of the study and, if supported by statistical analysis, they suggest that fat does make a contribution to one's ability to distinguish different meats.

We worked under the hypothesis that the major part of flavor of most meats is broth-like, and were interested in more information on the role of fat and its relation to the differences that may play a part in our ability to distinguish one meat from another. To be certain we were measuring chicken flavor, we decided to use chicken, beef, and pork in our studies and offer broths from each, asking panel members to identify each sample. Our assumption was that if the panel could identify the material we then were dealing with chicken flavor as such.

Chicken broth was prepared from the skin and meat of the leg, thigh, and breast. The following is a discussion of the materials presented to the panel.

1. A "reflux broth" was prepared with a modified crude fiber extraction apparatus with condensers in each beaker to prevent loss of volatiles.

2. "Beaker broth" was prepared in the same way but the condensers were removed and watch glasses used as covers. Highly volatile materials could escape, but excessive evaporation was prevented.

3. "Fat stripped meat broth" was prepared by freeze-drying meat and stripping of fat by means of the Soxlet apparatus, with petroleum ether as a solvent.

4. Meat dialyzate was prepared from ground meat and dialyzed for 24 hours against distilled water in a cold room at 32° to 34°F. By use of extreme care in preparation of the sample, bacterial growth in the dialyses was negligible after 24 hours.

5. "Ion exchange effluent" was prepared with Amberlite IR 120, polystyrene bead cation exchange resin and Amberlite IR 45 anion exchange resin. To prevent gelation when fat-stripped meat broth was passed through the columns heat was applied with infra-red heat lamps.

Table 1. Meat broths (% correct identification)

	Chicken	Beef	Pork
Reflux broth without fat	69	69	77
Reflux broth with fat	83	94	85
Basal broth with fat	58	67	48

Table 1 shows the percentages of correct identification when the panel was served different broths. The reflux broth without fat is simply reflux broth prepared as indicated above, the fat being removed after the broth was filtered through glasswool into a separatory funnel and the aqueous layer drawn off. The reflux broth with fat was simply the aqueous layer from the broth with fat taken during separation added back to the broth and the material homogenized. To rule out influence of texture on identification of broths containing fat, the same amount of fat was added to both the chicken, beef, and pork samples. This meant that beef and pork did not receive the amount of fat that was inherent to the material, but did receive the same amount as was inherent to the chicken. This procedure would seem to penalize beef and pork if flavoring materials are present in the fat, and we intend to repeat these experiments with bland oil to keep the fat level the same, yet include the amount of fat originally present. Basal broth with fat (third item) was a synthetic broth, as described by Dr. Bouthilet in early work with chicken flavor, which was prepared with gelatin and monosodium glutamate to simulate the protein and nonprotein portions of chicken broth. Fat added had been separated from the aqueous layer of each of the meat broths. From the figures shown we can see that there appears to be an increase in frequency of correct identification when fat is added to the broth. It appears that addition of broth fat enhances the ability to distinguish the particular product. Even though the broths were not scored for intensity, it is doubtful whether flavor intensity with added fat was appreciably greater.

Table 2. Meat broths (% correct identification)

	Chicken	Beef	Pork
Reflux broth without fat	42	45	83
Reflux broth with fat	75	91	88
Beaker broth without fat	33	42	67
Beaker broth with fat	78	95	67

The question was raised whether or not using the reflux method of preparing the broth might retain volatile materials which possibly inhibit the ability to distinguish between broths. Therefore, we conducted a test with reflux broth with and without fat and what we called "beaker" broth, both with and without fat. In this trial the samples were presented singly and we would expect 33% correct identification if the panel was not able to recognize the product. Table 2 shows that the panel was unable to identify chicken broth without fat. When fat was added, they were able to identify the broth. Apparently addition of fat to pork broth has very little effect on ability to distinguish the product. Apparently there is no difference between broths prepared under reflux and in an open beaker as far as ability to distinguish the product is concerned.

Table 3. Meat broths (% correct identification)

	Chicken	Beef	Pork
Reflux broth without fat and salt	46	38	79
Reflux broth with fat and salt	63	96	67

These data follow the same pattern as those in the previous table. With addition of salt (Table 3) the level of identification was lowered for both chicken and pork. Here again, in the case of both beef and chicken, addition of fat to the broth enhanced ability to select the product.

If addition of broth fat to the aqueous portion of broth improved the panel's ability to distinguish the products, one might expect the fat to be readily distinguished. This, however, did not seem to be the case. The panel was unable to recognize broth fats from any of the materials, nor were they able to distinguish between uncooked fat which had been pressed from meat samples after they had been subjected to freeze drying. When this raw pressed fat was brought to boiling and subsequently tasted, the panel was able to distinghish pork fat; however, they were unable to identify either chicken or beef. The results would lead one to believe that fat may be a physical phenomenon as far as

taste is concerned. However, until further tests are conducted it is questionable whether it should be ruled out as a contributor to aroma or overall flavor as it related to aroma.

Table 4. Ether-stripped meat broths (% correct identification)

	Chicken	Beef	Pork
Taste	73	95	70
Aroma	85	90	92

Table 4 indicates that by either taste or aroma this material was readily identified by the panel. On the basis of taste, beef was more readily identifiable than was either chicken or pork. However, on the basis of aroma there was little difference between products, all being identified by the panel. We believe these tests show that there certainly are flavoring components in that portion of the meat which has been stripped of fat which characterized these products. This may provide a clue, however, that while we know from Mr. Pippen's work that fat is a poor solvent for chicken flavor it may be a solvent for that portion of the overall flavor which permits us to distinguish the product as either chicken, beef, or pork.

Table 5. Ether-stripped meat broths, ion-exchange effluent (% correct identification by tasting)

	Chicken	Beef	Pork
Control	65	90	60
IR 120 (cation)	60	90	70
IR 45 (anion)	55	70	60

Passing fat-stripped meat broth through the cation exchanger had little if any effect on ability to distinguish one from another. This adds further evidence to findings of Mr. Pippen and his group that quantitative removal of nitrogenous portion of chicken broth distillate by ion exchange had no effect upon flavor intensity. Passing the broth through an anion exchange did not completely remove the flavor components. These results (Table 5) may be questionable due to the nature of the material and trouble with gelation which may have prevented quantitative exchange.

Table 6. Ether-stripped meat broths ion exchange effluent (% correct identification by aroma)

	Chicken	Beef	Pork
Control	73	87	87
IR 120 (cation)	30	33	60
IR 45 (anion)	33	67	30

Materials treated in the same way but tested for aroma (Table 6) seemed quite different; both exchangers appear to remove the aromatic portion of flavor which contributed to ability to distinguish one meat broth from another. It should be pointed out that ion exchange is drastic, due to the high degree of ionization in the resin and the extremes of pH in the effluents which could alter delicate flavor precursors.

Table 7. Meat dialyzates (% correct identification)

	Chicken	Beef	Pork
Taste, uncooked	63	47	60
Taste, cooked	67	53	53
Aroma, uncooked	33	47	42
Aroma, cooked	28	36	44

It would seem that at least part of the characteristic flavor is dialyzable and can be detected in the uncooked as well as the cooked material. As far as aroma is concerned, it would appear that aromatic portions are not dialyzable and material cannot be distinguished on the basis of aroma, either cooked or uncooked.

Summary

We may conclude that addition of fat which has been cooked in association with meat exerts an effect on the panel's ability to recognize either chicken or beef broth, but not pork broth. The flavor constituents which aid in distinguishing products are present in broth prepared from meat stripped of all fat.

Under the conditions of these tests, the panel was unable to distinguish between broth fats or fat pressed from freeze-dried meat. However, they could identify pork fat if it had been heated.

From ion-exchange tests it would appear that the characteristic portion in the fat-stripped meat broth was not removed by either cation or anion exchange on the basis of taste tests. However, when aroma was used as the criterion, both cation and anion exchangers appear to reduce the panel's ability to detect one product from another.

It would appear that those components contributing to taste are dialyzable for either chicken, beef, or pork, but that those aromatic portions which permit characterization of chicken, beef, or pork are not dialyzable.

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POULTRY FLAVOR CONSTITUENTS, A REVIEW OF CHEMICAL STUDIES IN THE WESTERN REGIONAL RESEARCH LABORATORY

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Industrial know-how is frequently unable to cope with problems concerned with flavor improvements or flavor changes which may arise through diversification of products or modification of production and processing practices. This undesirable situation may be remedied by building a reservoir of fundamental information about the flavor of poultry products. This report reviews fundamental studies, particularly on chemical aspects of chicken flavor, which have been carried out at this Laboratory and suggests areas where further research is required.

Crude Carcass Fractions as a Source of Flavor. Evaluation of chicken broth has shown that chicken meat is the best source of extractable flavor and that bone and skin are poorer sources. While this result is straightforward for broth, it can be predicted that the role of skin in flavor becomes more complex in the case of roasted and particularly fried chicken where seasonings are usually deposited directly on the skin and conditions are more favorable for development of pyrogenic flavor. The role that skin plays in the development of the flavorful crust on fried chicken remains to be determined.

Further studies have shown that a major portion of flavor precursors are readily extracted from raw, cut-up chicken meat with cold water. Furthermore, it was found that a detectable amount of flavor may be extracted during ice-slush chilling of ready-to-cook carcasses. Hence the water-soluble nature of flavor precursors can have practical implications in processing steps where chicken may be unduly exposed to extracting action of water. It was determined that a substantial portion of the flavor in such extracts was contributed by its inorganic content. Taste tests showed that flavor loss resulting from ice-slush chilling was most readily detected in broth, less in a roast, and hardly at all in fried chicken. An investigation of the composition of both heated and unheated extract of raw chicken meat is needed to determine the nature of flavor precursors and to provide clues about how cooked flavor develops.

Limited results on relation of chicken fat to chicken flavor have been obtained. In studies on broth, large differences in amount of fat cooked with meat to prepare broth made no significant difference in flavor of the aqueous broth. When broth was prepared from defatted meat and compared to a control containing the normal amount of fat, no significant difference was found in flavor

of the aqueous portion of the broth. The aroma of the broth prepared from the fat-containing sample was, however, found to be significantly stronger. Fat skimmed from chicken broth received an average panel score of less than 1, compared to an average value of 5 for the aqueous phase, on a scale of 10 for strong and zero for no chicken flavor.

It must be concluded, in these particular experiments, that chicken fat made a minor contribution to what was recognized as chicken flavor. However, it is obvious that these results do not necessarily apply to other forms of cooked chicken. Nor can we ignore the possibility that fat makes an indirect contribution, perhaps by giving rise to secondary products, by acting as a solvent for seasoning, or by affecting texture. Obviously additional results are needed before we can come to general conclusions regarding the importance of chicken fat to chicken flavor. Perhaps a good place to start would be to determine whether there is anything unique about the flavor of chicken fat compared to flavor of other fats.

Volatile Components. Concentrated chicken broth, reconstituted with broth distillate, was selected by panel members as having more flavor than the same concentrate reconstituted with water; Thus there are volatile flavoring components in the distillate, and the distillate provides a suitable medium for investigation of some of the chemistry of volatile flavor.

Nitrogen in broth distillate was first investigated. A typical distillate showed a pH of 9.7 and a nitrogen content of 37 gamma per ml. Treatment with a cation exchange resin resulted in quantitative removal of nitrogen, and the pH of the distillate dropped to 4.4. This treatment was accompanied by a definite change in character of distillate aroma; it became more pungent and more characteristic of chicken flavor. This observation was verified by a panel which selected a sample of broth concentrate reconstituted with nitrogen-free distillate over the same concentrate reconstituted with the unfractionated distillate. Nitrogen absorbed on the resin was eluted with acid and recovered as the chloride salt. From a portion of the salt a benzene sulfonamide, identical with the corresponding derivative of ammonia, was prepared. Re-distillation of the chloride salts from sodium hydroxyde into redistilled hydrochloric acid, followed by recovery of the salts by evaporation, yielded pure ammonium chloride. It was concluded that essentially all of the nitrogen in broth distillate was present as ammonia and that, except for its overwhelming effect on pH of the distillate it has little importance as a flavoring substance.

Sulfur was also investigated. It was established that sulfide sulfur appears in chicken broth distillate and that it is converted rather rapidly (77% in 47 hours) to nonsulfide form when the distillate is exposed to air at room

temperature. In freshly prepared distillate, total sulfur and sulfide sulfur were found to be equal. This result showing that most if not all of the volatile sulfur of cooked chicken is sulfide, was confirmed in another experiment in which over 97% of the sulfur evolved during cooking was accounted for as sulfide. Concentration of sulfide in broth distillate was found to be of the order of 0.5 to 3 gamma per ml. It was determined that odor of sulfide, added as H_2S to chicken broth, could be readily detected when added at concentrations as low as 0.25 gamma per ml. These results indicate that sulfide, as H_2S, makes a contribution to chicken flavor. The nature of the precursors of hydrogen sulfide and the reactions which lead to its formation during cooking are areas which should be investigated. Furthermore, it has not been established that trace amounts of other volatile forms of sulfur are absent. This is a matter of importance when the extreme flavor potency of some of these sulfur compounds is considered. There is a need here for development of methods for determining trace amounts of various types of volatile sulfur.

Carbonyls are another class of compounds which have been found among the volatile components of cooked chicken. 2, 4-Dinitrophenylhydrazones of 17 carbonyl compounds, including diacetyl, and representatives of the 2-alkanones, n-alkanals, n-alk-2-enals, and n-alka-2, 4-dienals were identified among the volatile components of chicken cooked under oxidation favoring conditions. Recent results show that similar carbonyl compounds are present, but to lesser extent, among volatile components of chicken cooked in water for about 4 hours. Since these are present under normal conditions, they must be considered as potential flavoring components. Some evidence as to their role in flavor can be obtained by taste tests to determine threshold levels of detection and flavor characteristics of the carbonyl compounds. Also quantitative methods for determination of carbonyl in various fractions of chicken are needed to provide data which may help determine the role these compounds play. In addition to carbonyl compounds identified there is evidence that others remain to be identified. Additional work to determine the origin or nature of precursors of carbonyl compounds is indicated.

Additional Areas Where Work is Needed. Since only limited work has been done on the fundamental nature of poultry flavor, it is easy to think of areas, in addition to those discussed above, where studies might be pursued. It may be worth while to mention a few.

The general area of the chemistry of off flavors in poultry products has received little attention. Studies may suggest ways to predict, postpone, or avoid appearance of off-flavors.

Work is needed to characterize the conditions, reactants, and products involved in the formation of so-called "brown" flavors which are suspected to be important in the flavor of gravies and fried chicken. In this area, studies of sugar in poultry meat and its possible interaction with amino acids, peptides or proteins to form flavoring compounds should be investigated.

The relationship between chicken fat and chicken flavor needs clarification. From a practical point of view, studies are needed to determine how use of chicken fat in various foods affects flavor of the final products. Chemically, we need to determine whether chicken fat, during processing, storage, and cooking gives rise to secondary products which may have flavor significance.

It has become apparent that many classical procedures for separation and analysis cannot be applied directly to poultry. Progress in the chemistry of poultry flavor therefore calls for a continued search for methods adaptable to this commodity and for better and faster methods for separation and quantitative determination of individual components.

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FEATHER MEAL AS A PROTEIN CONCENTRATE--EFFECT OF PROCESSING ON COMPOSITION

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The problem of disposal or utilization of the inedible portions of poultry has become increasingly important with the continued trend of the processing industry toward greater centralization. Offal, consisting of heads, feet, entrails, and blood can be converted to useful by-products by established rendering practices. Feathers, however, presented a more difficult problem and it was not until 1950, when Binkley and Vasak published AIC-274, Production of a Friable Meal from Feathers (available here), that a satisfactory method for utilizing large amounts of feathers was made available. The subsequent use of feather meal as a protein feed supplement, instead of as fertilizer, as originally anticipated, led to this work on the effects of processing and to other work on nutritional value.

The amino acid composition, except for tryptophane, of chicken and turkey feathers and of a number of laboratory and commercial feather meals was determined by quantitative paper chromatography (Table 1). The similarity of composition indicates equal usefulness as raw material for feather meal.

Table 1. Amino acid composition of feathers (adjusted to 16% N)

	Chicken	Turkey		Chicken	Turkey
Arginine	7.0	8.9	Cystine	8.7	8.7
Glycine	9.8	9.3	Tyrosine	3.0	3.6
Histidine	0.6	0.9			
Isoleucine	5.5	5.1	Alanine	4.9	5.4
Leucine	8.1	8.5	Aspartic acid	6.5	7.1
Lysine	1.9	1.6	Glutamic acid	10.0	8.9
Methionine	0.4	0.4	Proline	12.0	11.3
Phenylalanine	5.1	5.5	Serine	12.2	12.7
Threonine	5.0	5.0			
Tryptophane	(0.5)*		Nitrogen	15.1	14.7
Valine	8.8	8.7			

*Literature value.

Table 2 shows only the amino acids affected by processing. The only significant effect of processing by steam alone was found to be reduction in amount of cystine and appearance of lanthionine. The effect of processing with prior addition of 5% hydrated lime is also shown, because of commercial interest

in such a process, probably as a means of preservation and odor abatement. This modification not only resulted in greater loss of cystine and appearance of more lanthionine but also in losses of threonine and serine and probably of arginine. Loss of arginine is not apparent from our results but has been found elsewhere.

Table 2. Amino acids affected by processing (adjusted to 16% N)

	Chicken feathers	Laboratory normal	Feather meals +5% lime	Commercial
Cystine	8.7	5.7	3.6 (1)*	5.8
Lanthionine	0.0	2.0	4.3	1.7
Arginine	7.0	7.0	7.1 (4.8)*	6.3
Threonine	5.0	5.1	3.7	4.5
Serine	12.2	12.1	8.5	10.4

*Microbiological assay of commercial product obtained by Dr. G. F. Combs, University of Maryland.

Table 3 shows the changes that occur with increasingly severe processing of clean feathers in laboratory equipment. The treatments used were the minimum required to produce a reasonably friable meal (30 min.), the maximum that could be used without loss due to solubilization (240 min.) and an intermediate "normal" treatment (90 min.). The amount of cystine lost rather than the amount remaining is given to emphasize the coinciding appearance of lanthionine.

Table 3. Effects of increasing time at 30 lbs./sq. in. as per cent of protein (16% nitrogen)

Time	Pepsin-HCl digestibility	Cystine loss	Lanthionine	Amino nitrogen	Ammonia nitrogen
0	16	0.0	0.0	0.21	0.00
30 min.	65.1	1.1	1.3	0.22	0.01
60 min.	70.6	3.1	2.1	0.26	0.10
240 min.	82.6	3.1	2.6	0.42	0.17

The greatest and most important change shown in Table 3 is the approximately 5-fold increase in pepsin-HCl digestibility. The other chemical changes shown are comparatively quite small and particularly in view of the fact that lanthionine, like cystine, can also form cross-links between peptide chains, do not seem sufficient to account for the large change in digestibility.

Since the feather proteins are predominately keratins, which are highly oriented in the native state, and since it is known that denaturation or disorientation of proteins results in increased digestibility, a process similar to denaturation could result in the changes found during processing of feather meal. While denaturation usually requires only comparatively mild treatment, it is apparent that in this case, where keratin orientation is stabilized by the disulfide cross-links of cystine, the treatment necessary is that required to break the disulfide bonds. Thus, as a result of loss of orientation which can occur during conversion of cystine to lanthionine, feather keratin becomes susceptible to enzyme attack even though disulfide linkages are subsequently replaced by the thioether linkages of lanthionine.

THE NUTRITIVE EVALUATION OF FEATHER MEAL AS A PROTEIN SOURCE FOR THE GROWING CHICK

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The keratin proteins have generally been considered to be of little nutritive value because of their structure, insolubility, and consequent indigestibility. Before 1950, attempts to use powdered keratin proteins as dietary sources of protein met with little success. Binkley and Vasak (1950) described a process for the production of a friable meal from feathers. As a result of this processing technique, interest has grown in the use of feathers as poultry feedstuffs.

Naber and Morgan (1955) and Wilder, Ostby, and Gregory (1955) demonstrated that commercially produced feather meal could be used in chick starting diets to replace small amounts of protein from soybean oil meal, meat scrap, fish meal and milk by-products.

Naber and Morgan (1956) showed that feather meal was capable of replacing one-fourth of the protein in a broiler ration containing large amounts of corn and soybean oil meal fortified with fish meal, dried whey product, and methionine. In addition, commercial feather meal was shown to contain vitamin B_{12} and unidentified growth factors which satisfactorily replaced fish meal and dried whey in a broiler ration. Nitrogen retention studies indicated that chicks receiving one-fourth of their protein intake from feather meal retained as much dietary nitrogen as those fed control rations.

Lillie, Sizemore, and Denton (1956) found that commercial feather meal replaced fish meal as a source of unidentified growth factors in a corn-soybean oil meal base chick starter ration. During the past 2 years other papers have been published to confirm the findings indicated in the references cited above.

Little information is now available on the amino acid supplementation of feather meal protein and on the relationship of processing conditions to the digestibility and availability of amino acids from feather protein. Recent information on this subject has been presented by Barnett and Morgan (1958). They found that feather meal as the sole protein source in semi-purified diets failed to support a maximum growth rate of chicks when supplemented with those amino acids known to be limiting in feather meal protein. It was further shown that the histidine content of feather meal was poorly available to the chick.

Recent work by Naber and Touchburn (1959) has been concerned with amino acid supplementation and processing of feather meal protein. When chicks were fed simplified corn-feather meal diets, amino acid supplements markedly improved growth and nitrogen retention. The limiting amino acids in order of

importance were lysine, methionine, tryptophane, histidine, and arginine. The growth rate of chicks fed the corn-feather meal diet plus the 5 amino acids was 70% of that for control chicks fed a corn-soybean oil meal diet.

In a ration where feather meal, soybean oil meal, and corn each contributed one-third of the protein intake, lysine and methionine supplementation alone produced a maximum growth rate. When experimentally processed feather meals were compared in diets where one-third of the protein was contributed by feather meal, all samples except raw ground feathers produced satisfactory growth rates.

In corn-feather meal diets where 60% of the protein was furnished by the experimentally processed feather meals some distinction could be made between the processed meals. All feather meal samples with pepsin digestibilities of 70% or more appeared to give satisfactory growth rates.

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